Plant Growth Regulator Injury to Soybean

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A Review of PGR Injury

Abnormal soybean leaf development, often described as cupping or puckering, has been widely reported across Illinois and other Midwestern states during past growing seasons. The abnormal growth is most commonly found in soybean fields that received a postemergence herbicide application, but many reports originated from soybean fields in which no herbicide had been applied. The abnormal growth symptoms most often reported include: extreme cupping of trifoliolate leaves, usually most pronounced on the upper or youngest trifoliolates (below); veins of affected leaves assume a parallel orientation instead of the usual net venation pattern (left); and overall, soybean plants are stunted compared with plants not demonstrating the aforementioned symptoms.

One of the most difficult challenges related to soybean leaf cupping is *determining the causal agent*. Several theories have been proposed that attempt to explain the phenomenon of soybean leaf cupping. These include: the possibility that the abnormal growth is a physiological response of the soybean plant to adverse growing or environmental conditions; injury caused by a postemergence soybean herbicide might have disrupted the soybean plant's hormonal balance and resulted in the cupped leaves; or the soybean plant somehow has been exposed to one of the plant growth regulator (PGR) herbicides used primarily in corn. While the theories that adverse environmental conditions or disruption of the soybean plant's hormonal balance induce soybean leaf cupping may seem likely, they are not well supported by the scientific literature. However, the scientific literature is filled with evidence that describes the effects of plant growth regulator herbicides on soybean growth and development.

Determining *how a soybean plant has been exposed* to a PGR herbicide used in corn may be readily apparent in many cases, but requires a great deal of investigation in other instances. Three avenues of exposure include physical drift during the application, vapor drift within a few days following the application, and residues remaining on application equipment are applied directly to soybean along with a postemergence soybean herbicide.

Will yield loss occur if soybean are injured by a PGR herbicide during the growing season? The simple answer is that any yield response is dependent upon several factors. Previous research has demonstrated, in general, that the likelihood of soybean yield loss *increases*: 1) when exposure to the PGR herbicide occurs closer to the time of soybean *reproductive development* (flowering or later), and 2) as the *dose* of the PGR herbicide increases. For example, a high-dose exposure during early vegetative development may not result in a yield loss, but exposure of the same or lower dose once flowering has begun is more likely to cause soybean yield loss. PGR herbicide injury that results in a yield loss is also commonly accompanied by more severe symptoms such as death of the growing point, swollen or cracked stems, and curved pods.

Previous research on soybean response to PGR herbicides examined the effects of exposure to *only the PGR herbicide*. However, if the soybeans are exposed to a PGR herbicide via residues dislodged from application equipment, they will also be exposed to the soybean herbicide being applied for weed control. It was previously unknown whether or not the presence of other herbicides would intensify PGR herbicide injury on soybean. Given the increase in postemergence herbicide use in soybean, the likelihood of soybean exposure to a PGR herbicide jointly with a soybean herbicide has greatly increased.

New Research Findings

✓**Soybean vary in their sensitivity to the different PGR herbicides.**
Among the PGR herbicides that are currently used near soybean fields in Illinois, soybean are most sensitive to dicamba, the active ingredient in Clarity, Banvel, and Distinct as well as other premix herbicides like Marksman. An application of 1% of a corn field use rate of Clarity reduced soybean yield by 6% when applied at the V3 stage and 12% when applied at the V7 stage. Soybean are also sensitive to clopyralid, the active ingredient in Stinger. One percent of a Stinger rate in corn caused less injury than 1% of a Clarity rate, but 3.2% of a Stinger rate reduced soybean yield by as much as 48% when applied at V7. Soybean are much less sensitive to 2,4-D than Clarity or Stinger. Soybean yield was not reduced from 10% of a 2,4-D use rate in corn, but was reduced by as much as 25% from an application of 32% of a 2,4-D use rate. Also, soybean are less injured by 1% of a use rate of Distinct than they are by an equal rate of Clarity. Clarity and Distinct both contain dicamba, but there is less dicamba in a field use rate of Distinct due to another chemical, diflufenzopyr. Diflufenzopyr increases the toxicity of dicamba on broadleaf weeds, but does not appear have an equivalent effect on soybean.

✓**Some postemergence soybean herbicides can increase PGR herbicide injury in soybean.**
Clarity was applied to RR soybean alone at 1% of a field use rate for corn and then the same rate was applied with Pursuit, Raptor, Flexstar, or glyphosate. Flexstar + Clarity (red bar in Figure 1) significantly reduced yield more than Clarity alone (blue bar) when applied at an early vegetative stage. In a late rescue treatment just before flowering, Pursuit, Raptor, or Flexstar + Clarity (red bars in Figure 2) also reduced yield more than Clarity alone (blue bar). Glyphosate did not significantly affect the yield decrease from Clarity (green bar in Figure 2). This is important given that PGR herbicide residues remaining in application equipment used for soybean is one of the most common ways that soybean are injured by PGR herbicides. A large increase in the use of postemergence herbicides over the past several years has increased the potential for this source of off-target injury. Although glyphosate did not significantly increase Clarity injury, or the resulting yield loss, using the same equipment to apply glyphosate following a PGR herbicide may still be a concern since glyphosate is often used for late weed escapes and Clarity can be more damaging at a later soybean growth stage. It is very difficult to completely clean PGR herbicide residues from application equipment. It was recently shown that after spraying with Clarity and following recommended guidelines to clean application equipment, Clarity residues were still detectable in the following spray solution (Proost, et al. 2004. Dicamba injury to soybean. http://ipcm.wisc.edu/pubs/pest/Dicamba2004.htm).

Summary

- **Soybean sensitivity to PGR herbicides varies.**
  - Clarity > Distinct > Stinger > 2, 4-D.
- **Soybean yield loss from PGR herbicides is more likely to occur if exposure occurs during reproductive periods than during vegetative growth.**
  - Also dependent upon dose of exposure.
- **Other postemergence herbicides can increase soybean yield loss resulting from PGRs.**
  - Clarity plus Flexstar, Pursuit, or Raptor reduced yield more than Clarity alone.
- **Current research: Develop a field diagnostic test that can determine if soybean plants have been exposed to PGR herbicides.**

Figure 1. Soybean yield following herbicide applications at the V3 stage to RR soybean. Soybean herbicides were applied at field rates, while Clarity was applied at 1% of the field rate for corn.

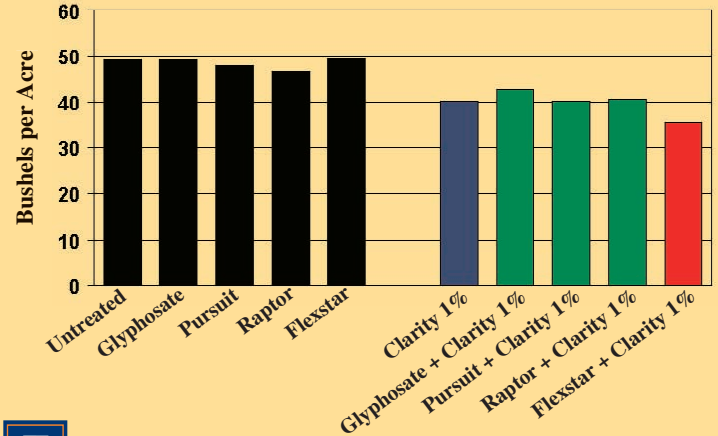
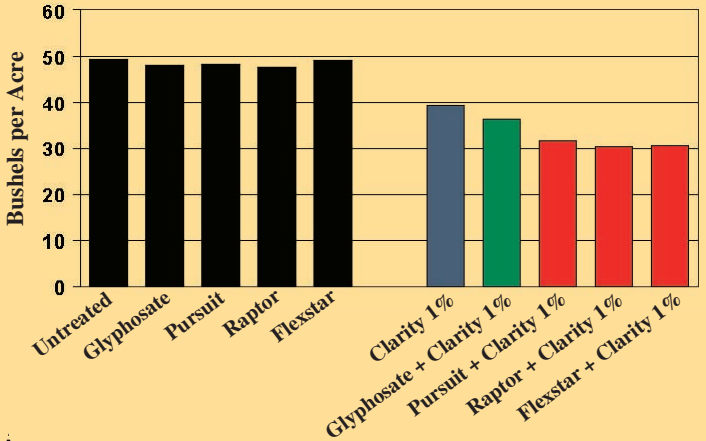


Figure 2. Soybean yield following herbicide applications at the V7 stage to RR soybean. Soybean herbicides were applied at field rates, while Clarity was applied at 1% of the field rate for corn.



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